Hubble Space Telescope (HST)
Vision 2000 Control Center System (CCS)

System Monitoring (SYM) Subsystem

Recover Faults (REF)

System and Functional Requirements

Prepared for

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Abstract

This document presents the system and functional requirements for the Hubble Space Telescope (HST) Vision 2000 Control Center System (CCS) System Monitoring (SYM) Subsystem. This document addresses only the Recover Faults (REF) part of SYM.

Preface

This is a living document and is intended to be a working description of the SYM REF subsystem. It is not a formal document promising delivery of the items described herein. It is intended to be a guiding influence in the design and development of the application, to remind the developers about the needs and priorities of the end users.

0. OVERVIEW

System Monitoring (SYM) provides the capability for monitoring the health and safety of the Space Network (includes NCC, STGT, JSC, and GSTDN) and the HST spacecraft. SYM has two major functions: Detect Faults (DTF)) and Recover Faults (REF). The DTF functionality is not covered in this document.

The REF capability is responsible for responding to anomalies related to the health and safety of the Space Network (SN) and the HST in the following operational modes:

- EXT: Externally Generated Telemetry (FEP) and Commands (CMD)
  - Real-Time (actual current state)
  - Simulation (using external simulated data)
- RPL: Replay Saved Historical Telemetry and Commands
  - Automatic playback : merged telemetry
  - User-requested playback: real-time replay or merged telemetry
  - Simulation/test data and scenarios

The DTF system will compare true state data (what the HST or SN is actually doing) and expected state data (what DTF thinks the HST or SN ought to be doing) to determine if there are any differences. When miscompares between the true state and expected state are reported by the DTF subsystem, supporting data will be collected and a recommendation will be made regarding the cause. These miscompares will be logged, and appropriate actions taken (e.g., report to mission engineers, issue a command, notify other functions, etc.) .

1.0 Recover Faults Description

Recover Faults (REF) has two major functions: Analyze Miscompare (AM) and Implement Actions (IA).

The Analyze Miscompares function accepts filtered CCS event messages from the CCS Manage Events function. In this case, the filtered CCS event messages are simply notification from DTF that a miscompare or recovery has happened. The CCS Manage Events is responsible for filtering the events that it receives from all subsystems and routing them to the correct destination process. There is additional information available about the CCS Event Management process on the world-wide web (ccs.gsfc.nasa.gov/ccspages/teaminfo/pat/ma_doc.htm). The title of the document is listed as "Manage Events Functional Requirements for the Hubble Space Telescope Vision 2000 Project".

The AM function records the initial information about the miscompares that DTF has encountered. As more information is available regarding a particular miscompare, this information will be updated with the status of all steps in the isolation and recovery process. The AM function determines, via an inferencing capability, the most probable cause of the miscompare and chooses an approved response from a list. This list of approved responses is determined by the ME's and is passed to the Implement Action function.

The Implement Actions function performs the actions as determined by the approved response which is selected by the AM function. These actions include issuing/ recommending commands, alerting Mission Engineers, and notifying other functions of REF conclusions. The REF subsystem will send all generated events (i.e. the actions) to the Manage Events for dissemination to the correct destination process or end-user.

The requirements in the following sections apply to all three modes of operation (real-time, background, and simulation), unless explicitly stated otherwise using the following notation:

- Real-Time (RT)
- Background (BG)
- Simulation (SIM)

1.1 ANALYZE MISCOMPARES

The following section of the document presents the functional and detail level requirements for the *Recover Faults (REF), Analyze Miscompares (AM)* function. The description of requirement for the AM function has been divided into four sections: inputs, manage miscompare, inferencing capability, and outputs.

1.1.1 INPUTS

The input requirements define all external and internal inputs that are required for the analyze miscompare function. The internal inputs are items that must be transferred between its' major processes (i.e. manage miscompare and the inferencing capability).

1.1.1.1 The REF AM shall receive, from the DTF subsystem, via the Manage Events function, an event message notifying it that a miscompare or a miscompare recovery has occurred. (Source: Level 2 DDTF)

1.1.1.2 The REF AM shall request the following information, regarding a miscompare, from the true and expected state tables provided by DTF:

- mnemonic id
- telemetry format
- data source
- conversion (EU/raw)
- TS value
- TS time stamp
- TS flags
- ES value
- ES tolerance
- ES time stamp
- criticality
- miscompare/recovery flag
- miscompare/recovery time of occurrence

* (Source: DLPs 4.02.05.01.03 - 04, 4.01.03.01.03 - 04, 4.03.04.01.03 - 04, 4.02.02.01.09, 4.02.05.02.01, 4.01.03.02.01, 4.03.04.02.01)

1.1.1.3 True state data shall be obtained from either a short term state table repository or from the long term state data repository. Expected state data shall be obtained from the short term state table repository.

1.1.1.4 The REF AM shall receive, from the DTF subsystem, an end of compare message. This is an indication that DTF is no longer receiving HST/SN data, and is therefore not comparing anything. This message shall include whether HST/SN data were processed for this cycle. When HST/SN data processed is indicated, the last miscompare processed time shall be updated. This time shall be used in computing the miscompare density, duration and interval

statistics for a miscompare. (Source: DLPs 4.02.05.01.05, 4.01.03.01.05, 4.03.04.01.05)

1.1.1.5 The REF AM shall receive, from the Manage Events function, filtered event messages from other processes. These event messages contain information pertinent to the health and safety of the SN and the HST as well as notification of actions implemented and responses to them. (Source: Top-Down Architecture, DLP: 4.02.05.02.07, 4.01.03.02.05, 4.03.04.02.07)

1.1.1.6 The REF AM shall request data from the Perform Analysis and Trendingsystem.(Source: DLPs 4.02.05.02.01, 4.01.03.02.01, 4.03.04.02.01)

1.1.1.7 The REF AM shall request data from the Data Management subsystem archive.(Source: DLPs 4.02.05.02.01, 4.01.03.02.01, 4.03.04.02.01)

- The REF AM shall request Telemetry Limits information from the Data Management subsystem.(Source: DLP 4.02.02.01.08)

- The REF AM shall request historical miscompare data from the Data Management subsystem. (BG) (Source: DLPs 4.02.05.06.02, 4.01.03.06.02, 4.03.04.06.02, 4.02.05.02.01, 4.01.03.02.01, 4.03.04.02.0, 4.02.05.06.02, 4.01.03.06.02, 4.03.04.06.02)

1.1.1.8 The REF AM shall allow the CCS user access to the knowledge base information.(Source: DLPs 4.02.05.06.01, 4.01.03.06.01, 4.03.04.06.01)

1.1.1.9 The REF AM shall read approved responses from a list of approved responses. (Source: DLPs 4.02.05.02.03 , 4.01.03.02.03, 4.03.04.02.03, 4.02.05.05.01 , 4.01.03.05.01, 4.03.04.05.01)

1.1.1.10 The REF AM shall allow the CCS user to update status field information in the MMST including closing miscompares, specifying action implemented and responses to them. (Source: Top Down Architecture)

1.1.2 MANAGE MISCOMPARE

The Manage Miscompares process handles any tasks related to the processing of miscompare and recovery events received from DTF. This includes creation and update of a Master Miscompare Status Table (MMST). This table contains all information (see requirement 1.1.1.2) necessary for documenting all open miscompares and their resolutions. Once resolved, the information will be moved to a long term archive file. Manage Miscompares will also control the queuing of other external (e.g. Legacy code) processes and rules as needed to resolve the miscompares. These activities will require a priority scheme to be followed.

1.1.2.1 The REF AM shall initialize and maintain a Master Miscompare Status Table (MMST).(Source: DLPs 4.02.05.01.01, 4.01.03.01.01, 4.03.04.01.01)

1.1.2.2 The REF AM MMST shall include all of the information identified in requirement 1.1.1.2 plus:

- source identifier (REF or ground monitor),
- analysis status,
- violated limit level
- miscompare density, duration, or interval statistics ,
- correlation record (relationship to another miscompare),
- action initiated fields, and
- resolution.

* (Source: DLPs 4.02.05.01.01, 4.01.03.01.01, 4.03.04.01.01, 4.02.05.01.03, 4.01.03.01.03, 4.03.04.01.03, 4.02.05.01.10, 4.01.03.01.10, 4.03.04.01.10, 4.02.05.02.02, 4.01.03.02.02, 4.03.04.02.02, 4.02.05.05.08, 4.01.03.05.08, 4.03.04.05.08)

1.1.2.3 The REF AM shall, upon recognition of a new miscompare, assign a unique miscompare ID, and record the time of occurrence and the current time in the MMST. (Source: DLPs 4.02.05.01.06, 4.01.03.01.06, 4.03.04.01.06)

1.1.2.4 The REF AM shall be responsible for computing, for each miscompare, the average miscompare density (number of occurrences of that miscompares over a specified period of time), duration of miscompare, and average interval between consecutive occurrences of that miscompares. This information shall be recorded in the MMST. (Source: DLPs 4.02.05.01.08, 4.01.03.01.08, 4.03.04.01.08)

1.1.2.5 The REF AM shall determine, for a miscompare in process, if an inference process (i.e. possible a rule) needs to be triggered based on one or more of these factors:

- miscompare density, duration, or interval statistics
- violated limit level

- criticality
- status of any analysis already triggered or queued for this micompare sequence.

* (Source: DLPs 4.02.05.01.09, 4.01.03.01.09, 4.03.04.01.09)

1.1.2.6 The REF AM shall be able to activate an external process to aid in the miscompare cause resolution task and record the status of all such activities/actions in the MMST. The activation of these processes are based on queue position (i.e., criticality) and resource (CPU) availability. (Source: DLPs 4.02.05.01.10, 4.01.03.01.10, 4.03.04.01.10, 4.02.05.01.01, 4.01.03.01.01, 4.03.04.01.01)

1.1.2.7 The REF AM miscompare cause resolution tasks may include collection of data from the following sources:

- MMST
- local SYM state data table
- Data Management subsystem archive
- external process analysis results
- Analysis & Trending products

* (Source: DLPs 4.02.05.06.02, 4.01.03.06.02, 4.03.04.06.02, 4.02.05.02.01, 4.01.03.02.01, 4.03.04.02.01)

1.1.2.8 The REF AM shall track the status of requested actions and update the MMST with this information. (RT, SIM)(Source: DLPs 4.02.05.01.11, 4.03.04.01.11, 4.02.05.01.12, 4.03.04.01.12)

1.1.2.9 The REF AM shall update the MMST if the requested action does not return a response within a specified period of time. (RT, SIM) (Source: DLPs 4.02.05.01.12, 4.03.04.01.12, 4.02.05.05.07, 4.03.04.05.07)

1.1.2.10 The REF AM shall update the MMST with the approved response. (Source: DLPs 4.02.05.02.07 , 4.01.03.02.05, 4.03.04.02.07)

1.1.2.11 The REF AM shall be able to accept miscompare actions from an internal process or from a CCS user. (RT, SIM) (Source: DLPs 4.02.05.01.11 , 4.03.04.01.11, 4.02.02.04.01)

1.1.2.12 The REF AM shall determine when miscompares should be closed and update the MMST with the status. The closure of a miscompare shall be based on the following conditions:

- average density becomes sufficiently low
- all associated analysis and actions have been completed
- verification has been received that a requested action has been completed (RT, SIM)
- closed by CCS user.

* (Source: DLPs 4.02.05.01.13, 4.01.03.01.11, 4.03.04.01.13, 4.02.05.01.11, 4.03.04.01.11)

1.1.2.13 The REF AM shall compare real-time and background miscompare results to aid in the identification of false anomalies recorded by the real-time system. This comparison shall be performed as a routine occurrence (when historical data becomes available), or upon request in the course of resolving a miscompare. Upon resolution of the differences, the MMST shall be updated with the outcome. Actions shall be initiated only for any miscompares which have not been previously identified by the real-time process, or whose results differ from the real-time process.(BG)(Source: DLPs 4.01.03.06.03, 4.02.02.03.06)

1.1.3 INFERENCING CAPABILITY

Using information provided in the MMST, the inferencing processes will determine possible cause(s) for the miscompare and provide a suggested course of action to the CCS Event Manager. This determination may be provided using any current inferencing tools available.

1.1.3.1 The REF AM shall provide the capability for the CCS user to add/delete data to be monitored within any of the inferencing tools. In the case of a rule-based inferencing tool the CCS user shall be allowed to add/delete/change applicable rules within the rule base. It shall be possible to make modifications without recompiling or reinitializing the tools. (BG, SIM) (Source: DLPs 4.02.05.01.02 , 4.01.03.01.02, 4.03.04.01.02)

1.1.3.2 The REF AM shall trigger appropriate inference processes for miscompares in progress. These may trigger on:

- miscompare duration
- miscompare density
- violated limit level (yellow, red)
- criticality
- status of requested analysis
- requested action response exceeded time limit

* (Source: DLPs 4.02.05.01.09, 4.01.03.01.09, 4.03.04.01.09, 4.02.05.01.12 , 4.01.03.01.12, 4.03.04.01.12)

1.1.3.3 The REF AM shall queue processes according to the criticality of the analysis need. (Source: DLPs 4.02.05.01.09 , 4.01.03.01.09, 4.03.04.01.09)

1.1.3.4 The REF AM shall attempt, using the inferencing capabilities, to determine the possible cause(s) of a miscompare. "Unrecognized Condition" is a valid outcome of this analysis. (Source: DLPs 4.02.05.02.02 , 4.01.03.02.02, 4.03.04.02.02)

1.1.3.5 The REF AM shall include, but is not limited to, processing of the following types of miscompares:

- Ground System configuration failure(Source: DLP 3.01.02.07-09)
- Maximum number of uplink retransmission exceeded(Source: DLP 3.01.02.04.03, 3.01.02.06.08)
- FINATT processing - commanded attitude vs. true attitude miscompare(Source: DLP 4.01.01.07.04, 4.02.03.02.08)
- OBSINT processing - RGA bias miscompare (Source: DLP 4.01.01.07.09)
- NASCOM block data quality issues (Source: DLP 4.02.01.01.04, 4.03.01.01.04)

- Attitude processing - Attitude Reference Update (ARU) request(Source: DLP 4.02.03.02.09-10)

1.1.3.6 The REF AM shall, based on determination of possible cause, select a response from a list of approved responses. This response shall include a time window within which it must be activated and whether verification is required. Examples of possible responses are:

- generate command request (RT, SIM),
- alert ME,
- suspend analysis and revisit miscompare after set time, and
- log micompare.

* (Source: DLPs 4.02.05.02.03 , 4.01.03.02.03, 4.03.04.02.03, 4.02.05.05.01 , 4.01.03.05.01, 4.03.04.05.01)

1.1.3.7 The REF AM shall always perform the log miscompare option in the course of miscompare resolution.

1.1.4 OUTPUTS

The outputs from the Analyze Miscompare function are identified as various report capabilities, data being passed to internal or external processes. The internal exchange of data may be between any of the identified major processes (i.e. manage miscompare, inferencing capability).

1.1.4.1 The REF AM shall provide the capability for the CCS user to view miscompare information via GUI display or printed report capability. The REF AM shall allow the user to select the time frame and subset of miscompares and/or mnemonics from which to report.(Source: DLPs 4.02.05.06.03 , 4.01.03.06.04, 4.03.04.06.03)

1.1.4.2 The REF AM shall allow the user to view the current status of miscompares by subsystem, including queue of analysis to be done and log of miscompares over a specified time period. This shall be done via GIU. (Source: DLPs 4.02.05.01.15 , 4.01.03.01.13, 4.03.04.01.15, 4.02.04.05.03 , 4.03.03.05.03)

1.1.4.3 The REF AM shall allow the user to produce a report using the miscompare log and the MMST information via GIU. This report will assist the CCS user in identifying miscompare sequences of a particular type to determine the frequency of regular recurring problems. (Source: DLPs 4.02.05.06.02 , 4.01.03.06.02, 4.03.04.06.02)

1.1.4.4 The REF AM shall produce a report of the comparison of real-time and background miscompare results. This shall be done via GIU. (BG) (Source: DLPs 4.01.03.06.03)

1.1.4.5 The REF AM shall record all miscompares, analysis and actions taken to the master miscompare status table. This record shall be sent to the Data Management subsystem to be archived. (Source: DLPs 4.02.05.01.07, 4.02.05.01.14, 4.02.05.02.05 - 06, 4.01.03.01.07, 4.01.03.01.12, 4.01.03.02.04, 4.01.03.04.01, 4.03.04.01.07, 4.03.04.01.14, 4.03.04.02.05 - 06, 4.01.01.05.02-03)

1.1.4.6 The REF AM shall provide the approved response information to the Implement Action function.

1.1.4.7 The REF AM function shall be able to send failure and status messages, regarding the status of the AM process, to the CCS Manager.

1.1.4.8 The REF AM shall send all generated events to the Manage Events function for logging and archiving.

1.2 Implement Action

The following section of the document presents the functional and detail level requirements for the REF, *Implement Action (IA)* function**.** The description of requirement for the AM function has been divided into three sections: inputs, actions, and outputs.

1.2.1 Inputs

The input requirements define all internal and external inputs that are required for the Implement Action function. The internal inputs are items that must be transferred between its' major processes. At this time there is only one major processes identified.

1.1.2.1 The REF IA shall be able to accept the approved response selection from REF AM. (Source: DLPs 4.02.05.02.03 , 4.01.03.02.03, 4.03.04.02.03)

1.1.2.2 The REF IA shall be able to obtain Analysis and Trending products as necessary. (Source: DLPs 4.02.05.02.01 , 4.01.03.02.02, 4.03.04.02.02)

1.1.2.3 The REF IA shall receive, from the CCS Management subsystem, notification when an Mission Engineer has responded to an alert. (Source: DLPs 4.02.05.02.03 , 4.01.03.02.03, 4.03.04.02.03, 4.02.05.05.08 , 4.01.04.05.08, 4.03.04.05.08)

1.2.2 Actions

The Implement Action function takes the approved response selection from Analyze Miscompares and implements the action that is recommended.

1.2.2.1 The REF IA shall, based on the analysis results from the AM function, implement an action (response) from the AM selection from the list of approved actions. Examples of possible responses are:

- command recommendation (RT,SIM),
- alert Mission Engineer,
- suspend analysis and revisit miscompare after set time, and
- log micompare.

* (Source: DLPs 4.02.05.02.03 , 4.01.03.02.03, 4.03.04.02.03, 4.02.05.05.01 , 4.01.03.05.01, 4.03.04.05.01)

1.2.2.2 The REF IA shall have the capability to generate command requests to be sent, via SYM Control Sym, to the CCS Command Processing subsystem. These command requests shall indicate whether or not verification is required, and shall specify an activation time window if necessary. (R/T, SIM) (Source: DLPs 4.02.05.05.02 , 4.03.04.05.02, 3.01.04.02.02)

1.2.2.3 The REF IA shall receive confirmation/rejection of requested commands, from the CCS Command Processing subsystem (via SYM Control Sym), within the designated time frame, when verification is specified. If such notification is not received within the allowed time, the REF IA shall update the MMST with the current status of the implemented action. (R/T, SIM)(Source: DLPs 4.02.05.05.03-04 , 4.03.04.05.03-04)

1.2.2.4 The REF IA shall have the ability to withdraw a command request by sending a message to the CCS Command Processing subsystem (via SYM Conrol Sym), and update the MMST of the override. (R/T, SIM) (Source: DLPs 4.02.05.05.05-06 , 4.03.04.05.05-06)

1.2.2.5 The REF IA shall have the capability to issue a request to the CCS Management subsystem to alert appropriate MEs when necessary. (R/T, SIM) (Source: DLPs 4.02.05.02.03 , 4.03.04.02.03)

1.2.2.6 The REF IA shall receive, from the CCS Management subsystem, notification when an ME has responded to an alert so that no other ME will be alerted. If no acknowledgment is received within a specified period, the REF IA shall request an alert to another ME. (Source: DLPs 4.02.05.02.03 , 4.01.03.02.03, 4.03.04.02.03, 4.02.05.05.08 , 4.01.04.05.08, 4.03.04.05.08)

1.2.2.7 The REF IA shall be able to request Analysis and Trending products as necessary. (Source: DLPs 4.02.05.02.02 , 4.01.03.02.02, 4.03.04.02.02)

1.2.3.8 The REF IA shall have the capability to suspend analysis activity on a miscompare, and continue after some set time. (RT, SIM) (Source: DLPs 4.02.05.02.03, 4.01.03.02.03, 4.03.04.02.03)

1.2.3 OUTPUT

The outputs from the Implement Action function are identified event messages containing the actions recommended and taken, and data being passed to internal or external processes. The internal exchange of data may be between any of the identified major processes. At this time there is only one major process identified, IA.

1.2.3.1 The REF IA shall notify AM of any actions taken and responses to them for the purpose of updating the MMST. (Source: DLPs 4.02.05.02.07, 4.01.03.02.05, 4.03.04.02.07)

1.2.3.2 The REF IA shall be able to send event messages to the SYM Manage Events process for all significant failures and status updates. (Source: TDA)

1.2.3.3 The REF IA shall have the capability to send structured real-time command requests to CCS Command Processing subsystem (via SYM Control Sym). (Source: DLP 3.01.04.02.02)

1.2.3.4 The REF IA shall be able to send messages to CCS Management to support the “alert ME” approved response. (Source: DLPs 4.02.05.02.03 , 4.01.03.02.03, 4.03.04.02.03, 4.02.05.05.08 , 4.01.04.05.08, 4.03.04.05.08)